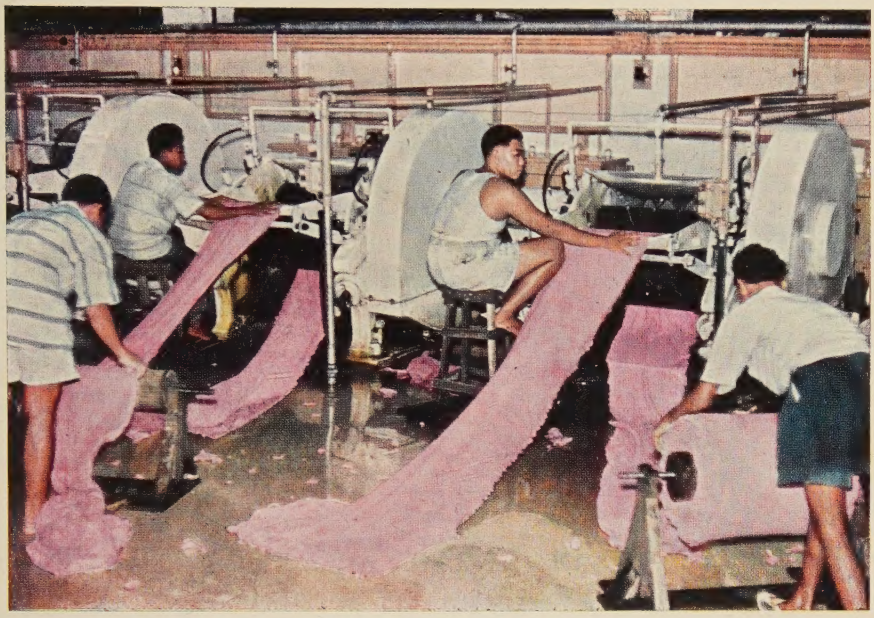
# PLANTERS' BULLETIN

## OF THE RUBBER RESEARCH INSTITUTE OF MALAYA



PLANTERS' BULLETIN THIRTYEIGHT

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Price
50 Cents

September
1958

# R R I

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# PLANTERS' BULLETIN

OF THE RUBBER RESEARCH INSTITUTE OF MALAYA

Kuala Lumpur September 1958 Number 38

## Editorial: Research Control

Since the days of Ridley there has been cooperation between natural rubber producers. The first chemist to work in Malaya on the curing of rubber had the joint financial backing of the members of the Rubber Growers' Association. Similarly, the funds for present day investigations on all aspects of rubber production are supported by every grower in the country, through the cess that is levied on his produce when it is exported.

International cooperation in research and propaganda for natural rubber was provided when, under the International Rubber Regulation Agreement of 1934, the International Rubber Research Board and the International Rubber Development Committee were created to serve the interests of the producing countries in the Far East. The remarkably rapid growth of the synthetic rubber industry during and after the last war has provided a further stimulus to the natural rubber producers to develop and integrate their research efforts.

For Malayan rubber producers the year 1957 was notable for the adoption by the industry of the broad principles set out in the 'report of the advisory committee enquiring into production, development, and consumption research in the natural rubber industry' – generally called the Blackman Committee Report. Implementation of the recommendations of the Report was commenced in 1957 with the revision of programmes of work of the three research organisations. Early in 1958, with the agreement of the industry, the cess on rubber was raised from 0.5 to 0.75 cents per pound, and the terms and conditions of service of the staff of these organisations were revised. Another step which is being taken, and which will have far reaching effects on the direction and conduct of research, is that a Controller of Research, Federation of Malaya, is to be appointed. His duties will include 'Chairmanship of the Malayan Rubber Fund Advisory Committee and coordination of all aspects of research and development in the natural rubber industry financed by the Malayan Rubber Fund' – to quote from the advertisement inviting applications for this most responsible post. It is made

It is with the greatest regret that we learn of the death of Sir Eric Miller, who for very many years has been one of the leaders of the rubber industry, and who has played an especially important part in pioneering research development.

clear that a man of highest ability is being sought. We understand that he will be assisted by scientific advisers, and that the independence of his position is to be guaranteed by legislation. He will have a wide range of duties, involving close liaison with research and development organisations and manufacturing interests outside Malaya.

We welcome the creation of this new appointment, strengthening the central planning of research on natural rubber and promising closer integration of the work of sister organisations, so that the problems confronting the industry can be attacked with renewed vigour.

# Drives for Crepeing Machinery

*We are indebted to the Wilkinson Process Rubber Company Limited for permission to publish the article presented here, based on their research into the production of Linatex crepe.*

THE FIRST RUBBER CREPEING MACHINERY of the present type was installed in Malaya and nearby countries in the early years of this century. It comprised suitably balanced batteries of five or six machines with rolls 24 or 26 inches wide, powered by a single 80 – 100 h.p. steam or oil engine through a line-shaft drive. Many rubber estates and factories are still using equipment installed between thirty and fifty years ago. Machines installed more recently, following past practice, have generally been of similar design.

The term 'line-shaft drive' generally refers to a common driving shaft which is run continuously, with countershafts driven from it through belts and pulleys to power individual machines. The power requirements of crepeing machines, however, are too great to be transferred by belts, which run at relatively low speeds. Here, therefore, we are using the term to mean a common backshaft running behind several adjacent machines, with clutches and driving pinions mounted directly on it.

Line-shaft drives are open to criticism in several ways. Firstly, there is the drawback that failure of the main power unit puts all the machines out of service at the same time. Secondly, repairs to the drive-shaft or to individual take-off clutches can also result in several machines being stopped unnecessarily. Thirdly, accidents have been caused by greasers servicing the long exposed lengths of shafting which are a feature of this type of drive. Lastly, power is wasted when the whole lineshaft system has to be started to run only one machine.

The question arises, when modernising old batteries or installing new machines of improved design, whether it would be better to have each machine individually driven. Effectively, this can only be done with electric motors. Much of the information needed in considering individual drives has not been generally available. The most important

requirements are to establish the size of motor for each machine in the battery, and the best pinion ratio, determining the differential speeds of the two rolls. It is also necessary to decide whether to use geared motors or conventional motors and gear-boxes, and whether to control the operation of the machines by electrical push-button or by a mechanical clutch.

## SIZE OF MOTOR

It might at first sight appear to be a fair assumption that the total horsepower required to drive the machines as a line-shaft battery can be distributed over a number of smaller motors for individual drives, so that in aggregate the horsepower is the same. In practice, however, this is not so, since each motor must have its own reserve capacity, whereas a single motor driving a battery of machines provides the reserve of power for any machine that may need it. The effect is nearly to double the installed horsepower of a battery of machines with individual motors, as compared with the same machines driven by line-shaft from a single motor, when allowance is made for standardisation of motor sizes. Two typical examples are:

*a* Ten crepeing machines driven from a single 130 h.p. motor required a total of 234 h.p. when fitted with individual drives.

*b* Three machines driven from a single 80 h.p. motor required 135 h.p. when individually driven.

In each case the installed horsepower was increased by about 75%, with a consequent lowering of the efficiency of the motors – an aspect of the question which weighs heavily against the adoption of individual drives. The prime cost of the motors is in an even greater adverse ratio, the total price of several small units sometimes being fully twice that of a single large unit, while starting equipment and gearboxes similarly cost more. Offset against these extra costs is the saving on the line shaft and clutches but, on balance, individual drives are more expensive and advantages must be found elsewhere if the idea is to be adopted.

## POWER REQUIREMENTS

We will consider first the function and action of a crepeing machine. In the machines with grooved rolls at the beginning of a battery, shapeless lumps of coagulum are changed into a long band of rough-textured crepe. This is achieved by the tearing action of the two rolls revolving at different speeds, coupled with a retaining pull as the rubber is compressed into the grooves on the rolls. In successive passes through three or four machines, the rubber is kneaded and forced into a band of crepe of roughly consistent width and thickness, with the shape imprint of the grooves on its surface.

In the smooth-roll machines at the end of the battery, the rubber is converted from the rough-textured material of loose dimensions into a long length of fine, smooth crepe, of relatively constant thickness and width. The action of the smooth-rolls is to stretch the crepe by virtue of the two rolls having different speeds, and to set the rubber in its stretched condition by the high pressure exerted between the rolls. The effect is shown in *Figure 1*, and the result of it is to reduce both the thickness and width of the band of crepe, only the former being desired.

For all machines, the speed of the back roll determines the rate of output. The operating speed should therefore be the fastest that is compatible with the operator exercising effective control over the crepe entering the roll nip. Experience has shown that the back roll speed should be between 20 and 24 r.p.m., with smooth machines running at near the lower limit.

The power required to run each type of creper has been found experimentally, on machines with rolls 14 inches in diameter and 32 or 36 inches long. The results given in the Table indicate the various operational ranges and the recommended sizes of motor, which have been limited to two only. This is advised in the interest of standardisation, to reduce the number of standby motors and spare parts that must be held. It should be noted that the load varies differently on the different machines. With macerators handling an intermittent feed, peak loads

POWER REQUIREMENTS OF CREPEING MACHINES

| *Machine* | *Operating range (h.p.)* | | *Maximum h.p. at rolls* | *Estimated 'no load' h.p.* | *Total h.p. required* | *Size of motor* |
|---|---|---|---|---|---|---|
| | *Coagulum* | *Remills* | | | | |
| First macerator | 10/20 | 20/38 | 38 | 2 | 40 | 45 |
| Second macerator | 20/27 | 20/28 | 28 | 2 | 30 | 45 |
| Spiral | 12/18 | 12/20 | 20 | 2 | 22 | 45 |
| Heavy diamond | 12/23 | 20/23 | 23 | 2 | 25 | 45 |
| Medium diamond | 10/25 | 10/23 | 25 | 2 | 27 | 45 |
| Light diamond | 7/10 | 7/10 | 10 | 1 | 11 | 17½ |
| Pressing smooth | 4/9 | 6/9 | 9 | 1 | 10 | 17½ |
| Finishing smooth | 4/8 | 5/8 | 8 | 1 | 9 | 17½ |

are usually only momentary. With spirals and diamonds (machines having rolls with spiral or diamond grooving) handling longer lengths of crepe and catering for both a single thickness pass and a double or triple 'bunching' pass, peak loads are sustained for longer periods.

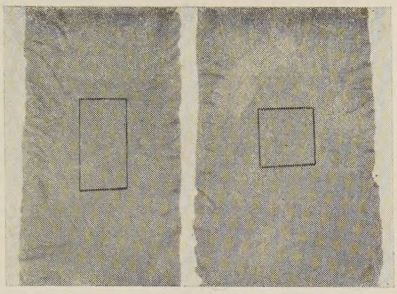


*Figure 1. A square marked on crepe before machining (right) becomes elongated after machining (left) and the width of the crepe is reduced.*

Smooths (machines with smooth rolls) carry a relatively constant load, the rubber handled by them being more uniform.

The work done by the smooth-roll machines can be derived approximately from a simple formula. The horsepower consumed is proportional to the width of crepe fed in ($W$), and to the ratio of the reduction in thickness ($R$) to the thickness of crepe fed in ($T$). The formula is thus:

$$\text{h.p. at rolls} = W \times \frac{R}{T} \times C$$

where $C$ is a constant taking into account the roll speed and the differential speed ratio of the two rolls. The value of $C$ has been found to be unity when $W$ is expressed in inches and when a pinion ratio of 0.58 is used. Values of $C$ for other pinion ratios can be found from *Figure 2*, derived from experimental data.

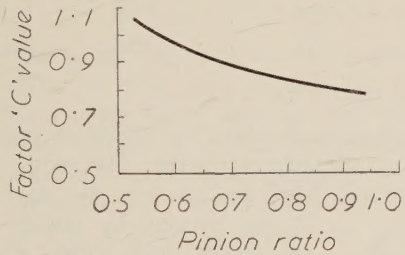



*Figure 2. Values of factor 'C' for various pinion ratios.*

PINION RATIO

Opinions differ on the question of which pinion ratio produces the finest crepe. To establish the effect of changing the pinion ratio, a smooth roll machine was modified to provide a separate drive to each roll, incorporating a chain drive to the front roll. By changing sprockets on the chain drive, the 'pinion ratio' was made variable between wide limits for a constant back roll speed. The results showed that the following statements can be made regarding smooth-roll machines.

*a* The wider the pinion ratio, the more work is done on the crepe for the power put in. As the speed of the front roll is reduced in

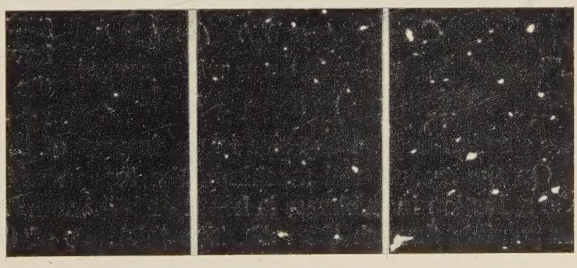


*Figure 3. Three samples of crepe in silhouette showing the effect on quality of pinion ratio: left, 0.58; centre 0.76; right, 0.90.*

relation to a constant-speed back roll, the combined 'stretching and setting' effect of the smooth rolls is greater, and, for the same roll clearance, both thickness and width are reduced.

*b* The quality of the crepe improves markedly as the pinion ratio is widened (*Figure 3*), the effect being paramount on the finishing machine, and of progressively less importance further back along the battery.

*c* The output of the machine is virtually unaffected by changes in the pinion ratio.

The effect of different pinion ratios on grooved-roll machines has not been studied, but the same principles will apply. It is possible, however, that the stretching action of a wide speed ratio combined with the holding effect of the grooves might result in a tearing action which is too vicious and will not produce a really homogeneous crepe. Taking all considerations into account, the following pinion ratios are recommended:

| *Machine* | *Teeth on back roll pinion* | *Teeth on front roll pinion* | *Pinion ratio* |
|---|---|---|---|
| Macerator | 22 | 27 | 0.82 |
| Spiral | 22 | 27 | 0.82 |
| Diamond | 20 | 29 | 0.69 |
| Smooth | 18 | 31 | 0.58 |

## WIDTH OF CREPE

With each successive pass through a crepeing machine the width of the crepe is reduced, by the stretching action already explained. The reduction in width can be made good, on grooved-roll machines at the start of the battery, by bunching two of three widths of crepe together and feeding a larger quantity of rubber into the rolls. Particular care is taken on the last grooved-roll machine to pass the widest possible crepe to the first smooth-roll machine. For this reason it is usual for the grooved-roll machines to have a greater width than the smooths (36 inches as against 32). The smooths are standardised on one size in the interest of interchangeability.

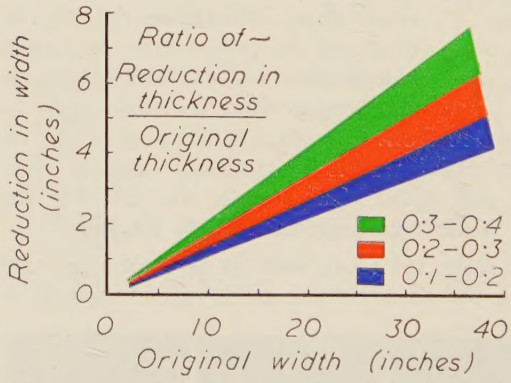



*Figure 4. Reduction in crepe width caused by a single pass through smooth rolls.*

On the smooth-roll machines, the loss in width which accompanies the reduction in thickness is kept to a minimum by having as few passes as possible through the rolls. The thickness of the crepe from the last

grooved-roll machine should therefore be kept to a minimum also, to reduce the work required after this stage. *Figure 4* drawn from test results on a machine with a 20 r.p.m. back roll and a pinion ratio of 0.58 indicates the reduction in width caused by a single pass, in relation to the thickness of crepe fed in, for various thickness-reduction ratios. The reduction in width is virtually unaffected by the ratio of the roll speeds, nor is it a function of the actual speed of the rolls. The graph, therefore, applies generally to all smooth-roll machines.

## CAPACITY OF CREPEING MACHINES

The composition of a crepeing battery depends on the output required. Since all crepe produced must pass through a finishing smooth-roll machine, it is the capacity of this which determines the output of a small battery. The output of a 32 inch finisher – the usual size – is between 100 and 300 lb per hour, depending on the quality and thickness of the crepe produced, and four or five other machines are generally used to support it. A macerator, however, has a much greater capacity, the output of one keeping three finishing smooths occupied, provided that sufficient intermediate machines are used.

## CHOICE OF MOTORS

The power required to start a machine under load – with rubber in the rolls – is twice that required to run it under normal operating conditions. This heavy starting load presents a difficulty in designing individual drives. It would be possible to provide motors which, though adequate for normal running, are not equal to starting the machines under load. It would mean that, whenever the operator found it necessary to stop the machine with rubber in the rolls (whilst awaiting fresh supplies, or to correct feed conditions, or through some fault in the machine) he would be forced to slacken back the front roll, remove the rubber, then re-set the roll position before starting up again. Apart from the difficulty of checking on the operators, especially when night shifts are worked, such an arrangement could hardly be regarded as satisfactory. It is better, therefore, to accept the alternative of providing motors which will start the machines under load.

One solution is to use slip-ring motors with specially designed resistance starters giving 200% full load torque on starting, with a relatively small increase in the current consumption – in the region of 250% of full load current. The alternative is to use squirrel-cage motors with direct-on starters giving 200% full load torque on starting, but at a cost of as much as 700% of full load current. This tremendous current surge may be objected to by the electricity authority concerned. In general, permission for large direct-on starters is given only where the installation is the sole offtake from a mains transformer or sub-station. Where this situation applies, as on many rubber estates, direct-on starting should be used. The great advantage of squirrel-cage motors

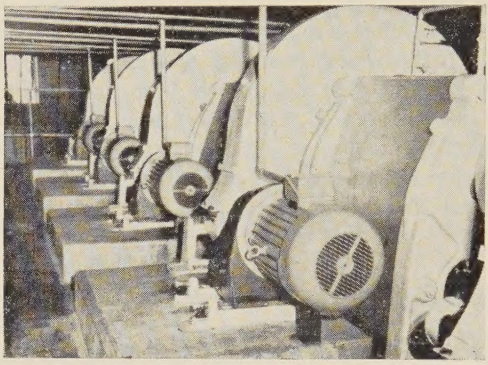


*Figure 5. A battery of machines individually driven by geared motors.*

with direct-on starters is that they cost only about half as much as slip-ring motors with resistance starters.

Where the crepeing machines are a few hundred yards from the transformer or sub-station there is a possibility that lights elsewhere on the line will be found to 'dip' when one of the bigger motors is started. It becomes a problem only when the distance from the transformer is really excessive, but the advice of the electricity authority should be taken on this point for all installations where the distance exceeds three hundred yards.

## STOP-START CONTROL

It is a distinct advantage of individual drives using direct-on starters that push-button controls can be fitted. If the stop/start box is mounted in a convenient position above one of the machine side-frames, the operator has far better control over the crepe than when clutches are used. The elimination of clutches also gives an appreciable saving in maintenance costs, as they become very troublesome after a few years service under tropical conditions in the generally wet surroundings of crepeing machinery.

## POWER FACTOR

A factor of considerable importance in relation to the size of motors for individual drives is the electrical power factor, which may be regarded as the proportion of the current put into the motor which is put to useful purpose in driving the machine. A crepeing machine which requires 20 h.p. for normal working will need perhaps 30 h.p. to overcome occasional peak loads and to assist in starting. The motor will, as a result, be running at a very low power factor. It is normal for electricity authorities to increase their

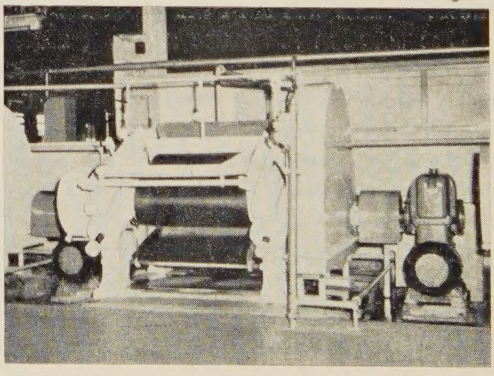


*Figure 6. Motor and gearbox assembly mounted between machines.*

charges when a consumer's power factor falls below 0.8, and this point should be borne in mind when designing individual drives. Power factor rectification equipment should be installed if a lower figure than 0.8 is regularly obtained, and the cost counted as a charge against individual drives.

## CENTRIFUGAL CLUTCH COUPLINGS

Some improvement in the power factor of individual drives can be achieved by fitting centrifugal clutch couplings between motor and gearbox, making it possible to reduce slightly the size of the motors. Pivoted shoes on the motor shaft are thrown outwards by centrifugal force as the motor speed increases, bringing them into friction contact with an internal drum on the gearbox shaft, and so taking the load up gently. The size of the motors can be reduced only to the extent that an allowance must otherwise be made for starting. The saving is about 10% of the motor rating.

With a solid coupling the motor is committed to acting against the full machine starting load immediately the 'start' button is pressed. Employing squirrel-cage motors with direct-on starters, 700% of the normal running current is taken to provide the driving force. As long as the resistance of the rubber in the rolls prevents the machine from turning, the starting current continues. After a short delay, the sustained torque overcomes the resistance of the rubber (assisted by a certain thinning of the crepe in the roll-nip due to the force applied) and the rolls start to turn. The motor is protected against overheating by an electrical 'trip' in the control gear, operating at a pre-determined period after the 'start' button has been pressed.

With a centrifugal clutch coupling the motor still takes the same 700% of normal current immediately the 'start' button is pressed, but the clutch action allows the motor to build up speed and the current to fall before the load is connected; so there is less likelihood of overloading and the cut-out tripping. As the motor speed increases, so does the torque, with the result that the clutch coupling introduces no perceptible delay in starting the machine, as compared with a solid coupling.

The choice of mounting for the motor and gearbox is dependent on whether or not a clutch coupling is to be used If a solid coupling is being considered there is a distinct advantage in fitting, instead of a motor with separate gearbox, a geared motor, which needs a minimum of lining up and is particularly easy to install. Geared motors generally will fit neatly behind the crepeing machine, parallel to the rolls, with no space wasted (*Figure 5*). With geared motors it is possible to install crepeing machines in less space than with back-shaft drives. The more usual motor/coupling/gearbox assembly can be accommodated in the same space as a back-shaft drive (*Figure 6*).

### BEARINGS

An important factor to be considered when installing individual drive crepeing machines is that the brass bearings usually employed require a considerable amount of running-in before settling down to a normal service. The effect of starting a machine with new bearing bushes is to increase the power required to drive the machines, often by two or three times the normal running load. This factor is not normally apparent on a line-shaft drive battery, for there is no way of recording extra power taken by one machine. But the extra power requirements of a machine fitted with an individual motor are such that the loads immediately after fitting new bearings will be in excess of the motor rating. Care should therefore be taken to avoid overloading the motor when new bearings have been fitted. It is advisable to run the machine for three days with the rolls open, followed by three days of light running on scrap rubber, before putting it into normal service. An ammeter on the control box will show when the bearings have been properly run-in.

The use of roller bearings in place of plain bearings has been advocated for crepeing machines for some time, and most manufacturers now offer the two types of bearing as alternatives. Among the advantages claimed for roller bearings is that the running load is reduced by at least 25%, and that the starting load is reduced even more. The motor sizes noted earlier can be reduced by 25% with confidence when roller bearings are incorporated. The saving on the installation costs of individual drives, which is relatively greater than the saving on line-shaft drives, more than covers the extra cost of the roller bearings.

### BARRING

One of the commonest problems encountered in crepeing is 'barring', which occurs when the rolls or bearings have worn down slightly and the pinion teeth no longer mesh properly. The resulting skidding of the rolls causes a series of ribs or bars to appear on the crepe surface. As soon as barring is noticed it is usual to change the rolls, pinions, or both. The special crepeing machine constructed for experiments on pinion ratios showed how the need for this is avoided, if the two rolls are individually driven. Instead of the back roll driving the front roll through roll-end pinions, as is usual, the gearbox output shaft is extended to carry a pinion driving the back roll and a chain sprocket driving the front roll. This arrangement automatically provides for the two rolls rotating in opposite directions, and it eliminates any possibility of barring.

### SAFETY

From the safety point of view individual drives are very much preferable to line-shaft drives. There is a minimum of exposed shafting, and when a machine is stopped for any reason there is no line-shaft or back-shaft continuing to revolve. Further, with individual motors it is possible to stop a machine almost instantaneously, using plug-braking –

a device which automatically reverses the direction of rotation of the magnetic field in the motor immediately the emergency stop is operated. With a line-shaft drive it is difficult to get the rolls to stop within three seconds of operating the emergency stop device.

### COMPARISON OF LINE-SHAFT DRIVE WITH INDIVIDUAL DRIVES

The advantages and disadvantages of individual drives may be summarised as follows:

| *Advantages* | *Disadvantages* |
|---|---|
| Individual control and operation of each machine | Need for power factor rectification |
| Push-button control | Higher initial cost |
| Increased safety for the operator and maintenance staff | Complexity of electric wiring, of necessity under wet conditions |
| Cleaner, quieter, and neater in appearance | Possibility of lights 'dipping' when starting |
| Improved emergency stop with plug-braking | Need for more technical skill in maintenance |

The greatest advantage of individual drives is that a breakdown on one machine does not affect the rest of the battery. In crepeing factories where it is essential to maintain continuous daily production, this consideration is so important that the additional expense of individual drives can confidently be regarded as warranted.

Another situation which favours individual drives arises from estates' gradually increasing production, as high yielding trees come to maturity. With line-shaft drive installations, when an existing battery is working to full capacity it is necessary to install another complete battery to handle the extra crop. For some time only one or two machines in the new battery might be needed, and the new power unit would be then very much underloaded, with a resultant low power factor and low efficiency. The problem does not arise where individual drive machines are installed, extra machines being added to the battery as they are required to cope with the extra crop.

The conclusion to be drawn is that individual drives are recommended where it is important to avoid a stoppage of work due to mechanical breakdown, or to have an installation that can be changed to suit a changing load. From the practical point of view there is nothing against individual drives. Eighteen crepeing machines motorised over the last three years have given completely satisfactory service. Some have run (on shift work) the equivalent of eight hours a day for six years, and required no more attention than minor adjustments to the electrical system.

D. PAPWORTH

# Intensive Tapping of Mature Rubber

ON THE HYPOTHESIS that tapping withdraws latex from a limited area of bark, situated mainly below the tapping cut, it might be expected that a tree could be tapped on two cuts provided that the areas of latex extraction do not overlap. This view was put forward in *Planters' Bulletin 25*, in the article 'Is Mature Rubber Undertapped?' It was supported by the early results of two experiments from which we now have derived considerably more information. The first, laid down in an old clone trial which had been budded in 1930, compared three tapping systems – a low cut alone, a high cut alone, and the two cuts combined. The results up to the end of 1955 have been given; here we summarise the results for thirty months – up to November 1956, when the design of the experiment was changed. The second experiment, laid down in 1955 in an area of unselected seedling trees planted in 1929, compares the same three tapping systems combined with yield stimulant applications. From this experiment we now have records for thirty months. In addition, we present some figures based on the first year's records from an area of young clonal rubber where we are observing the effects of intensive tapping with and without application of stimulant.

## OLD BUDDED RUBBER

The three tapping systems that have been compared are: half spiral cut alternate daily (S/2.d/2.100%) tapping of a low panel in bark of second renewal; half V cut alternate daily (V/2.d/2.100%) tapping of a high panel in virgin bark; two half cirfumference cuts alternate daily (2C/2.d/2.200%) tapping with one V cut high in virgin bark and one half spiral cut low in renewed bark, the yields of the two cuts being recorded separately.

There were nine clones in the experiment. Because the way they reacted was related to their yield capacity, they have been divided, for the purposes of presenting and discussing the results, into two groups: high yielding clones – PB 186, Tjir 1, Pil A44 and Pil B84; moderate and low yielding clones – AVROS 49, 50, 152, PB 23 and BD 5. The results are given in Table 1. It should be noted that the yield capacity of the two groups is not reflected in the yield figures for low cut tapping, which was in thin bark of second renewal. In Table 1 we have also included comparable results obtained with seedling trees in our second experiment, to which Table 2 refers. The three lines of figures from Table 2 which appear in Table 1 are yields obtained without application of a stimulant.

*High yielding clones* The outstanding feature of the first group of clones is the very high yield obtained from ladder tapping in virgin bark. The yield of trees tapped on the high cut only progressively fell as the cut moved down the tree towards the old panel, after two years becoming less than that of trees tapped on the low cut. The trees tapped on the double cut system initially gave nearly as much from each panel as the trees tapped on either one alone, but again the yield decreased

in time. That the yield of both panels should fall, as compared with trees tapped on either the high or low cut alone, shows that the two cuts influence each other by draining latex from overlapping bark areas. The higher rate of bark consumption on the high panel - between 13 and 14 inches a year compared with 11 or so on the low panel – reducing the distance of the two cuts at the rate of about $2\frac{1}{2}$ inches per year, would have slowly increased the interaction between them. Furthermore, both cuts were tapped on the same day. There is little doubt that the interaction would have been less had the cuts been tapped on different days. This was avoided as being difficult under estate conditions because tasks tapped on high cuts are generally about two thirds the size of those tapped on low cuts. Even so, tapping the high cuts and low cuts on alternate days is now practised on many estates in Malaya.

The advantages of a double cut system on high yielding material are obvious; but, because of the way the yield dropped in our experiment, and because it is impracticable to keep the tapping cuts further apart than 50 inches for a prolonged period, we suggest that the frequency of tapping should be reduced to third daily (2C/2.d/3.133%) with high and low cuts tapped on different days. Experiments are in progress to compare the third daily double cut system with the alternate daily system on high yielding budded trees planted in 1938, but insufficient results are available for conclusions to be drawn at this stage.

*Low and moderate yielding clones* – It is seen from Table 1 that the clones in the second group gave a disappointing response to high cut tapping. Analogy with the high yielding clones would lead one to expect the thick virgin bark to yield much more than the poor bark of the low panels, at least during the first year of ladder tapping, though not as much as the high yielders gave. Surprisingly, the high panels gave only about the same yield as the low panels. The sharp drop in yield of the high cuts in the fifth 6-month period is explained by the approach of the cut to the junction of virgin and renewed bark. On the double cut system of tapping, there is a suggestion of interaction between the two cuts, depressing their yield.

With these low and moderate yielding clones it is still possible approximately to double the yield by double cut tapping. We see no reason why they should not be so tapped as an ordinary estate practice, preferably tapping the two cuts on different days.

## UNSELECTED SEEDLINGS

Referring again to Table 1, it is seen that the yield of the unselected seedling trees was less from high cuts in virgin bark than from low cuts in renewed bark. This is a known reaction of seedling trees, and is explained in part by the tapering shape of the trunk making a high cut shorter than a low one. The reason why so many seedling areas are tapped on high cuts is simply that there is no suitable bark left at

TABLE 1. EFFECT OF THREE TAPPING SYSTEMS ON HIGH AND LOW YIELDING TREES

| Tapping system | Mean yield in grams per tree tapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | First 6 months | | | Second 6 months | | | Third 6 months | | | Fourth 6 months | | | Fifth 6 months | | |
| | Low cut | High cut | Total | Low cut | High cut | Total | Low cut | High cut | Total | Low cut | High cut | Total | Low cut | High cut | Total |
| *High yielding clones* | | | | | | | | | | | | | | | |
| S/2.d/2.100% | 29.3 | | | 35.0 | | | 41.4 | | | 43.2 | | | 43.4 | | |
| V/2.d/2.100% | | 69.5 | | | 57.8 | | | 51.1 | | | 47.3 | | | 41.8 | |
| 2C/2.d/2.200% | 24.7 | 63.9 | 88.6 | 26.3 | 50.7 | 77.0 | 29.3 | 46.9 | 76.2 | 32.2 | 42.2 | 74.4 | 32.5 | 30.2 | 62.7 |
| *Low and moderate yielding clones* | | | | | | | | | | | | | | | |
| S/2.d/2.100% | 25.4 | | | 27.6 | | | 31.5 | | | 34.1 | | | 33.7 | | |
| V/2.d/2.100% | | 28.9 | | | 31.1 | | | 33.1 | | | 30.6 | | | 24.8 | |
| 2C/2.d/2.200% | 24.1 | 27.1 | 51.2 | 26.7 | 29.7 | 56.4 | 27.8 | 28.7 | 56.4 | 30.4 | 28.1 | 58.5 | 30.2 | 22.6 | 52.8 |
| *Unselected seedlings* | | | | | | | | | | | | | | | |
| S/2.d/2.100% | 20.6 | | | 17.5 | | | 20.8 | | | 22.3 | | | 20.7 | | |
| V/2.d/2.100% | | 20.2 | | | 16.2 | | | 17.7 | | | 14.9 | | | 15.9 | |
| 2C/2.d/2.200% | 20.2 | 22.2 | 42.4 | 17.4 | 17.4 | 34.8 | 20.3 | 17.3 | 37.6 | 22.0 | 16.3 | 38.3 | 19.2 | 17.1 | 36.3 |

TABLE 2. EFFECT OF STIMULANT TREATMENT WITH DIFFERENT TAPPING SYSTEMS ON OLD UNSELECTED SEEDLING TREES

| *System of tapping and stimulation* | *Mean yield in grams per tree tapping* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *First 6 months* | | | *Second 6 months* | | | *Third 6 months* | | | *Fourth 6 months* | | | *Fifth 6 months* | | |
| | *Low cut* | *High cut* | *Total* | *Low cut* | *High cut* | *Total* | *Low cut* | *High cut* | *Total* | *Low cut* | *High cut* | *Total* | *Low cut* | *High cut* | *Total* |
| S/2.d/2.100% | | | | | | | | | | | | | | | |
| 1 No stimulation | 20.6 | | | 17.5 | | | 20.8 | | | 22.3 | | | 20.7 | | |
| 2 Bark application | 23.8 | | | 21.1 | | | 26.3 | | | 24.8 | | | 22.3 | | |
| 3 Panel application | 24.4 | | | 22.0 | | | 24.3 | | | 26.5 | | | 23.1 | | |
| V/2.d/2.100% | | | | | | | | | | | | | | | |
| 4 No stimulation | | 20.2 | | | 16.2 | | | 17.7 | | | 14.9 | | | 15.9 | |
| 5 Bark application | | 32.9 | | | 26.1 | | | 26.9 | | | 20.2 | | | 22.9 | |
| 6 Panel application | | 28.6 | | | 21.0 | | | 20.9 | | | 17.6 | | | 21.3 | |
| 2C/2.d/2.200% | | | | | | | | | | | | | | | |
| 7 No stimulation | 20.2 | 22.2 | 42.4 | 17.4 | 17.4 | 34.8 | 20.3 | 17.3 | 37.6 | 22.0 | 16.3 | 38.3 | 19.2 | 17.1 | 36.3 |
| 8 Bark appn > to high cut only < | 20.5 | 26.7 | 47.2 | 17.3 | 23.9 | 41.2 | 19.0 | 22.1 | 41.1 | 20.1 | 17.2 | 37.3 | 18.7 | 18.5 | 37.2 |
| 9 Panel appn > to high cut only < | 21.2 | 28.4 | 49.6 | 17.5 | 23.1 | 40.6 | 20.0 | 24.1 | 44.1 | 20.8 | 21.1 | 41.9 | 17.8 | 20.7 | 38.5 |
| 10 Bark appn > to low cut only < | 25.0 | 20.8 | 45.8 | 23.9 | 17.3 | 41.2 | 26.8 | 16.7 | 43.5 | 22.9 | 15.0 | 37.9 | 18.5 | 15.5 | 34.0 |
| 11 Panel appn > to low cut only < | 23.7 | 16.6 | 40.3 | 19.2 | 13.0 | 32.2 | 19.7 | 13.1 | 32.8 | 19.1 | 11.6 | 30.7 | 17.5 | 12.7 | 30.2 |
| 12 Bark appn > to both the cuts < | 26.0 | 29.1 | 55.1 | 23.1 | 25.9 | 49.0 | 24.0 | 27.4 | 51.4 | 21.4 | 20.9 | 42.3 | 19.4 | 19.9 | 39.3 |
| 13 Panel appn > to both the cuts < | 25.5 | 24.3 | 49.8 | 20.4 | 20.3 | 40.7 | 19.9 | 20.7 | 40.6 | 18.6 | 18.0 | 36.0 | 18.6 | 17.4 | 36.0 |
| 14 Bark application alternating between cuts | 24.2 | 27.8 | 52.0 | 24.1 | 22.6 | 46.7 | 22.7 | 21.5 | 44.2 | 19.4 | 17.3 | 36.7 | 19.4 | 19.5 | 38.9 |

low levels for tapping. In our experiment there was no interaction between the high and low cuts on the trees tapped on the double cut alternate daily system; the yield from each was fully equal to that obtained where the high or the low panel alone was tapped. It is therefore recommended that all unselected seedling trees be tapped on this system for the rest of their life, as an ordinary estate practice.

### YOUNG BUDDED RUBBER

Estates are not unnaturally reluctant to make young clonal rubber available to us for experiments on intensive tapping. We were therefore fortunate to obtain the use of one such area, which is to be mined in a few years time. The planting material was Glenshiel 1 buddings, eight years old and yielding over 1,000 pounds per acre per year on S/2.d/3.67% tapping. It was decided to continue to tap these young trees third daily, but on two half spiral cuts – one high and one low – both in virgin bark. Eighteen tapping tasks were treated in this manner. In addition, one task was tapped on a low cut only and another task on a high cut only. Finally, one task tapped 2S/2.d/3.133% was also given a stimulant application at intervals of six months, alternately to the high and low cuts.

| *Tapping system* | *Mean yield in lb/tree/year* | *Girth increment in inches* |
|---|---|---|
| S/2.d/3.67% (low cut) | 8.6 | 1.1 |
| S/2.d/3.67% (high cut) | 8.8 | 1.4 |
| 2S/2.d/3.133% (two cuts) | 14.2 | 0.5 |
| 2S/2.d/3.133% (two cuts, alternately stimulated) | 15.0 | 0.5 |

From the tabulated mean yields obtained in this experiment over the first twelve months, and the girth measurements, it is evident that the extra yield extracted through double cut tapping has been obtained at the expense of growth. Further, the effect of the stimulant combined with intensive tapping of these high yielding trees has been disappointing. A like result has been obtained in another experiment, where young clonal seedlings tapped on a single half circumference cut were treated with a yield stimulant. Only six months later it was clear that the rate of girthing of treated trees had been significantly retarded as compared with those left unstimulated. It appears that our recommendations for tapping young rubber (*Planters' Bulletin 29* page 25) provide for the maximum exploitation that can be expected from young high yielding trees.

### EFFECT OF YIELD STIMULANT

Unselected seedling trees planted in 1929 and being tapped in bark of second renewal were used to observe the effects of applying yield stimulant with different methods of tapping. Three tapping systems – S/2.d/2.100%; V/2.d/2.100%; 2C/2.d/2.100% – were combined with

three methods of applying the 2,4,5-T mixture – half yearly application below the cut to a three inch strip of scraped bark; monthly application above the cut; quarterly application alternately to the high and the low cut. A fuller description of the first two methods, which we shall refer to as 'bark application' and 'panel application', is given in the article on yield stimulation in *Planters' Bulletin 19*. The third method, for double cut tapping, consists simply in making bark applications alternately to the two cuts at intervals of three months. Each panel is thus treated once in six months. Altogether there were fourteen treatments (system of tapping and stimulation) in the experiment. In discussing the results, which are summarised in Table 2, we shall refer to each treatment by quoting the serial number at the left of the Table.

Where trees are tapped on one half spiral cut in bark of second renewal, a positive but poor response is obtained from stimulant application (systems 2 and 3 compared with system 1). A brief but high increase in yield was noted after bark application (system 2) but the yield invariably fell below that of the untreated trees when the first flush was over. Panel application (system 3) gave a small but significantly increased yield with no large fluctuation between applications. The treated panels, however, became seriously damaged. System 3 can therefore be used only on trees scheduled to be cut out, where the suitability of the panel for further tapping is of no interest.

Ladder tapping by itself (system 4) does not give an increased yield as compared with low cut tapping in reasonably good bark of second renewal (system 1), but trees tapped on high cuts in virgin bark reacted much better to yield stimulation (systems 5 and 6). The best result was obtained from bark application (system 5). Panel application (system 6) increased the yield to a lesser extent; again, the treated panels were seriously damaged.

Double cut tapping (system 7) resulted in a highly increased yield compared with single cut tapping (systems 1 and 4) without signs of interaction between the cuts. During the first eighteen months an additional effect of stimulant applied to the high cut (systems 8 and 9) is significant, though small. Thereafter the effect largely disappeared, interaction between the two panels having depressed the yield of the lower one in particular. Trees tapped on a double cut system and stimulated on the low cut only (systems 10 and 11) reacted differently according to the method of applying the stimulant. A marked lowering of the yield of the high cut which followed from panel application (system 11) was not noted for bark application (system 10).

In this experiment the highest yield was secured by bark application below both cuts (system 12). Even so, the effect largely disappeared after the second year of tapping. Panel application above both cuts (system 13) did not give a higher increase than when the high cut alone was stimulated (systems 8 and 9). This is not surprising, in view of the marked depressing effect on the yield of the high cut when stimulant

was applied above the low cut only (system 11).

Bark application alternately to the high and low cuts at intervals of three months (system 14) was expected to be the most productive but, as has been seen, system 12 was better in this experiment. The effect of the stimulant in both treatments disappeared after two years, as has been noted with all other 200% intensity tapping systems. It appears, therefore, that yield stimulant should not be used when trees are opened for double cut tapping at 200% intensity for a prolonged period. When the yield of the high cuts starts to drop off sharply, on approaching the junction between virgin and renewed bark, stimulation can be employed with advantage on the virgin bark island until the cut is in renewed bark. Otherwise yield stimulant should be used only during the last two years of double cut tapping, applying it below both cuts at intervals of six months.

## CONCLUSIONS

The following conclusions can be drawn from our experiments on intensive tapping.

*1* Old unselected seedlings and buddings of low or moderate yield capacity can be tapped on a double cut system (2C/2.d/2.200%) for a prolonged period. No stimulation should be used except as a temporary measure to overcome the loss of yield on passing a virgin bark island, and during the last two years before cutting the trees out.

*2* Old high yielding clones cannot be relied on to stand up to double cut alternate daily tapping for a long period. It is better to exploit the high yielding capacity of the virgin bark at high levels, initially by tapping on a single high cut. Our evidence is that such trees can be tapped for three years at 200% intensity on a double cut system, or on a less intense system such as 2C/2.d/3.133% for a longer period, before cutting the trees out for replanting. No stimulation should be used with double cut tapping except for passing a bark island and during the last two years of tapping.

It is known that high yielding clones tapped S/2.d/2.100% react favourably to yield stimulation. The method is most advantageously used when high cut tapping is done, but full advantage should be taken of the period of flush yield after opening the high cuts before applying the stimulant. Thereafter stimulant applications may be made at half yearly intervals.

*3* Young high yielding clones should not be tapped on a double cut system of more than 100% intensity, nor should they be treated with a yield stimulant.

*4* Yield stimulant should not be applied to renewing bark above the tapping cut if the panel is to be tapped again in the future. Panel application, however, is preferable on trees being tapped in bark of second or older renewal.

# Selective Control of Mikania and Rubber Seedlings by Spraying

THE ARTICLE ON COVER PLANTS, on pages 90-93 of *Planters' Bulletin 37*, indicates that the most suitable plants to grow in association with rubber are leguminous creepers and selected indigenous growths. The usual practice is to establish the legumes at the time of planting or replanting, and to allow colonisation by other plants of acceptable type. The sequence hoped for is that the creeping legumes will quickly form a complete cover which will last three or four years, during which time volunteer growths will increase to form a permanent ground cover when the legumes are shaded out.

Two problems that face the planter are: first, how to weed out *Mikania scandens* during the early stages when both the temporary and permanent ground covers are being established; second, how to prevent domination by rubber seedlings in mixed indigenous growths under mature rubber.

## MIKANIA

Where this ubiquitous weed becomes established it is impossible to maintain a cover of leguminous creepers, and the establishment of a more permanent cover of indigenous growths will be delayed if not prevented. Until the canopy of the rubber trees closes over, *Mikania* grows vigorously and swamps everything else. When it fades out, as it does when the rubber trees approach maturity, the surface of the ground is left bare or with a cover of grasses.

The cost of eliminating *Mikania* by hand weeding is prohibitive, but trials carried out on our Experiment Station have shown that it can be selectively controlled without permanent injury to other growths by spraying with a solution containing 1 lb of Fernoxone in 100 gallons of water. While *Mikania* is killed by the treatment, legumes growing with it are affected to various degrees. *Centrosema pubescens* and *Flemingia congesta*, being more resistant than the others, suffer only a slight setback. Leaves of *Pueraria phaseoloides* and *Calopogonium mucunoides* are severely scorched and drop off, but the stems are not killed and new leaves begin to emerge about a month after spraying. Recovery thereafter is fairly rapid and the cover remains free from *Mikania* for some three or four months, after which new growth, probably from seed, begins to appear. Spot spraying with the same strength solution (0.1%) of Fernoxone may be necessary, but probably not sooner than six months after the first treatment.

*Mikania* grows most vigorously in damp soil. It gets established first in depressions, swamps or valley bottoms, and from there spreads up the slopes to drier land. In replantings, and more especially in new plantings, it is a good policy to spray *Mikania* as soon as it appears in the low-lying places, to discourage its invasion of the rest of the area.

RUBBER SEEDLINGS

Under mature rubber, where upright indigenous growths are slashed at intervals, self-sown rubber seedlings soon assume dominance if not controlled. Their presence necessitates more frequent rounds of slashing, with increased cost of upkeep. The possibility of controlling the growth of rubber seedlings also by selective spraying has therefore been explored. Small scale trials on the Experiment Station have shown that it can be done without injury to indigenous growths by spraying with a solution containing half a pint of Floroxone in 100 gallons of water. The rubber seedlings suffer defoliation followed by dieback of the upper part of the stems, severely setting them back and allowing the other plants to develop more strongly. Rubber seedlings less than a year old may be killed by the treatment. Older seedlings, especially those which have been slashed previously, will throw out new shoots from the base of the stem. Spraying at intervals of six months or longer gives effective control, though the rubber seedlings are not eliminated.

Floroxone, like Fernoxone, is a hormone-type weedkiller. The risk of injury to the tapping panel through spray drift is negligible at the concentration recommended.

The action of both Fernoxone and Floroxone will be improved by adding a wetting agent at the rate of 4 fluid ounces per 100 gallons of spray fluid. The concentration of the herbicide should not be increased above the rates given, or there will be a danger of excessive damage to legumes and desirable species of indigenous cover plant.

# Leaf Sampling for Diagnosis of Nutrient Deficiency

ABNORMAL DEVELOPMENT OF PLANTS due to adverse growing conditions may take many forms, the most common of which is leaf discoloration. When the disorder is caused by a pest or disease, samples showing typical symptoms are usually all that is required. The article on the despatch of pathological specimens, on pages 77 and 78 of *Planters' Bulletin 31*, should be referred to for this purpose. But the most common cause of leaf discoloration is a serious deficiency of one or more of the several nutrient elements required for normal growth. On the other hand, a nutrient may be present in excessive amounts, causing injury to the leaf. In a few instances (for example, magnesium deficiency) it happens that the symptoms of the nutritional disorder are characteristic enough to be recognised with some confidence by visual inspection. The work recorded in our *Journal* Volume 14, Communication 300, entitled 'Visual Symptoms of Mineral Deficiencies of Hevea Brasiliensis', has made it possible to recognise deficiency symptoms of twelve

nutrients essential for the normal growth of hevea, but it is still desirable to confirm a diagnosis by chemical analysis of the leaves. The analysis of leaf samples is a service which we provide.

When leaf analysis is required for diagnostic purposes it is not sufficient to send only a specimen exhibiting the symptoms of the disorder. We also require samples from healthy plants in the same area for comparison. Furthermore, it is of great importance that the sampling of both healthy and affected plants follows a standard sampling procedure. In interpreting the results of leaf analysis we must assume that the sampling procedure carried out by the planter is identical with what we employ in evaluating the optimal concentrations of the various elements in the leaves. Unless the assumption is justified, the conclusions drawn may not be valid.

## LEAF SAMPLING PROCEDURES

Samples are required from normal and affected plants of the same age and from the same clonal block, in the same field or nursery. There are two situations to be provided for: (*a*) when sampling leaves from young, unbranched, rubber trees; (*b*) when sampling leaves from older, branched, rubber trees.

*a* When sampling leaves from unbranched rubber trees, select six normal plants and six affected plants, all without new flush growth at the top. The uppermost whorl of leaves should be fully mature. As far as it is practicable, select the groups of six trees from an area no greater than half an acre. Remove four whole leaves, each consisting of the leaf stalk and triplet of leaflets, from the top, second and third whorls of leaves. Keep the leaves from the different whorls separate, but combine those from corresponding whorls on each group of six plants so as to give three bulk samples from normal plants and three from affected plants — a top, second and third whorl sample from each. Sometimes the leaf discoloration appears only in the fourth or fifth whorl. Leaves from these whorls should then be sampled also.

*b* When sampling leaves from branched trees, select six normal trees and six affected trees, again from an area no greater than half an acre. From the top of the canopy of each tree select a high branch which is in the light, and which does not have a new flush of growth at the end. Remove from the branch the complete uppermost whorl, which must be fully mature. A simple method of collecting one of these top whorls is to send a climber up the tree equipped with a long pole carrying a hook at the end. By hooking the selected branch just behind the top whorl, and twisting the pole, the end of the branch can be snapped off. Combine the whorls from the normal trees to form one sample, and those from the affected trees to form a second sample.

All samples should be clearly labelled, placed between sheets of newspaper, and the parcel despatched to the Institute by the quickest route. Because it is important that we examine the samples while they are

fresh, they should not be despatched so as to arrive at the Institute during a weekend or a holiday.

### INFORMATION REQUIRED

Full details concerning the leaf samples will help us to make an accurate diagnosis of the nutritional disorder; equally, particulars about the plantation are necessary for us to frame advice as to remedial measures. Although it is not possible to lay down a schedule suitable for every case, the scheme given below indicates the sort of information required. Essential details are unlikely to be overlooked if it is followed systematically.

*Planting information*
Clones or clonal seedlings; dates of planting and budding; planting distances and present stand

*Cultivation*
Previous history of the land; nature of covers; system of control of covers

*Local conditions*
Soil type; slope and drainage of the land

*Manuring history*
Date, type and quantity of each fertiliser application

*Description of leaf disorder*
Symptoms described in some detail; area affected, the number or proportion of affected plants in the affected area and their distribution.

We have prepared a form on which the information called for above can be recorded when sending leaf samples to us. It is hoped that this procedure will facilitate the task both of the sender, in providing information, and of ourselves in dealing with it. Two copies of the form are enclosed with this issue*, to enable the sender to retain a duplicate. When we receive a completed form we shall forward two more as replacements.

## R. R. I. News

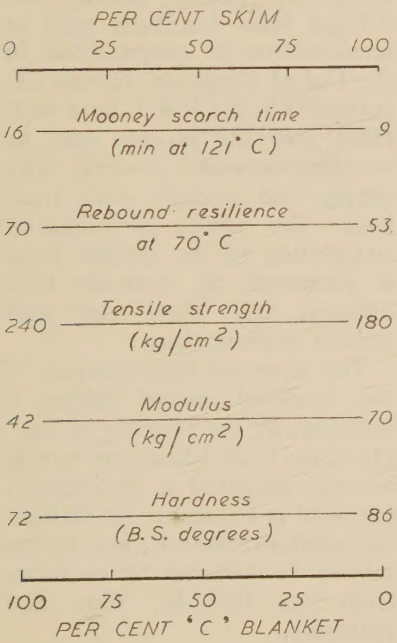
Mr E.C. Paardekooper, who joined the staff of the Botanical Division in June, has taken over the supervision of the Division's variety trials on estates as his main responsibility. Mr Paardekooper graduated from the State Agricultural University at Wageningen, Holland, in 1952. Since then he has been working in Indonesia at the C.P.V. Research Station in Bogor, Java, where he was in charge of research on breeding and selection of rubber. He contributed several articles on this topic to *De Bergcultures* (now *Menara Perkebunan*) and four papers to the *Achives for Rubber Cultivation.*

* Not included in overseas distributions as plant specimens must not be despatched from outside Malaya unless, as explained inside our front cover, phytosanitary regulations are complied with.

## Utilisation of Skim Rubbers

The spring issue of *Rubber Developments* contains an article by Mr H.C. Baker describing work carried out at the British Rubber Producers' Research Association on skim rubber, with suggestions as to how it can best be used by manufacturers. Copies of this issue can be obtained from the Kuala Lumpur office of the Natural Rubber Development Board.

The need to give manufacturers information on skim rubber and its uses arises both from its availability and from the considerable differences, as compared with ordinary grades, in its technical properties, which are not at all revealed by the conventional grading system. So marked are these differences that the occasional presence of undetected skim in consignments of rubber has caused serious trouble to some manufacturers and has given skim rubber an unnecessarily bad name.




The diagram shows the alteration in five physical properties of a tyre tread compound in which skim rubber has been progressively substituted by 'C' blanket. As the proportion of skim is raised, the Mooney scorch time, resilience and tensile strength decrease, while the modulus and hardness increase. By attention to the vulcanising system the tendency to premature vulcanisation (scorch) — its most serious processing defect — can be effectively controlled.

The abnormal properties of skim rubber originate from the much greater content of non-rubber substances. Its variability is also related to this, and arises largely from the greater variability in skim latices as compared with ordinary field latices. Most of the variability is due to differences in centrifugation procedure, and therefore tends to be small for any one estate and factory. It is for this reason that manufacturers who use skim rubber with advantage show a strong preference for purchasing their requirements from a single, known source.

The article gives technical data to show that skim rubber is inherently a good quality rubber which yields good ageing vulcanisates. It is almost invariably very clean and of good colour. It generally contains somewhat larger amounts of trace metals such as copper and manganese than ordinary grades, but not normally in excess of permitted limits. It can be used satisfactorily in applications where advantage can be taken of its greater ease of vulcanisation, the greater hardness of the derived vulcanisates, and the savings thus possible in expensive accelerators and fillers.

## Low Temperature Rubber

The essential 'rubberiness' of natural rubber is lost when it is cooled to low temperatures. In certain products – components for aircraft or for arctic vehicles, for example – this change in properties may render the rubber unserviceable. Research organisations working on natural rubber have set out to devise methods of producing, for these conditions, compounds which will be fully competitive with synthetic rubbers made specially for the same purpose.

Two distinct changes take place when rubber is cooled. The first is a slowing down of the normally rapid motion of the rubber molecules, leading to an increase in the stiffness of the rubber. As the temperature falls from – 20° to – 75°C the rubber is slowly transformed from an elastic material, becoming first leathery and then a brittle solid.

Investigators working at the British Rubber Producers' Research Association have found that rubberiness of natural rubber at low temperatures can be improved by incorporating in a particular way certain liquid plasticisers such as dioctyl sebacate. The temperature at which rubberiness is lost is reduced by as much as 20°C.

The second low temperature effect is a much slower, progressive stiffening of the rubber when it is kept for a time at temperatures ranging from about 0° down to – 45°C. This is due to the development of 'crystalline' regions, where the rubber molecules pack together in a regular pattern. The greater the proportion of rubber molecules crystallised, the less is the rubberiness of the whole. The rate of crystallisation is highest at about –25°C, and is greatly increased if the rubber is stretched. Although vulcanisation retards crystallisation, even a well vulcanised rubber compound will crystallise and lose its flexibility too rapidly to give satisfactory service under certain low temperature conditions.

Work at the B.R.P.R.A. and the Rubber Stichting in Holland has shown that the structure of the rubber molecule can be changed, making it much less liable to crystallisation at low temperature, by reacting it with a class of chemicals known as thiol acids. The most effective way of bringing about the reaction is by heating suitably stabilised rubber latex with a small amount of thiol acid in the presence of a catalyst – a process which has been patented by the B.R.P.R.A.

Because certain non-rubber substances present in some latices inhibit the reaction, doubly centrifuged latex has been used in semi-commercial preparations in the United Kingdom. Recent experiments at the R.R.I. have indicated how the process may be modified to make it work more simply and cheaply with fresh latex. The rubber produced by coagulation of the reacted latex is processed by methods little different from those used with normal smoked sheet.

The potential importance of this modified natural rubber is indicated by the Ministry of Supply in the United Kingdom having recently prepared a specification for what is known as 'crystallisation-inhibited rubber', and by the interest in it shown by enquiries from the U. S. A., Italy and Australia.

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